Introduction

Chapter Overview

Research and development (R&D) is widely recognized as being key to economic growth, along with factors such as "education, training, production engineering, design, and quality control" (Freeman and Soete 1999). Although R&D expenditures never have exceeded 3 percent of the U.S. economy and the precise effects of R&D have been difficult to measure (or sometimes even identify), scientific and government communities continue to study R&D expenditures to understand and improve the patterns of technological change that occur in the economy and society. As Rosenberg (1994) expressed:

> Science will often provide the capability to acquire information about technological alternatives that we do not presently possess, but *science does not make the acquisition of this information cost less.*…One valuable perspective on the cost of acquiring information is offered by the available data on R&D expenditures. These data are additionally valuable in showing the extent to which the generation and diffusion of knowledge has become an economic activity.

R&D decisionmaking—how much money different organizations spend and the areas of science or engineering on which they spend it—is critical to the future of the U.S. economy and national well-being. For this reason, the United States and many other nations collect extensive R&D expenditure data that are disseminated worldwide for study by analysts in a wide variety of fields.

In addition to indicating the direction of technological change, R&D expenditure data also measure the level of economic purchasing power that has been devoted to R&D projects compared with other economic activities. Industrial (private sector) funding of R&D, for example, may be considered an economic metric of how important R&D is to companies, since companies could easily devote those same funds to other business activities. Likewise, government support for R&D reflects governmental and societal commitment to scientific and engineering advancement, an objective that must compete for dollars against other functions served by discretionary government spending. The same basic notion is true for the other sectors that fund R&D: universities, colleges, and other nonprofit organizations.

Total R&D expenditures, therefore, reveal the perceived economic importance of R&D relative to all other economic activities. Because institutions invest in R&D without knowing the final outcome (if they did, then it would not be R&D), the amount they devote is based on their perception, rather than on their absolute knowledge, of R&D's value. Such information about R&D's perceived relative value is also extremely useful for economic decisionmaking. Of course, R&D data alone are not enough to accurately analyze the future growth of a field of study or an industrial sector, but they represent important input into such analyses. In addition to the total amount of R&D expenditures, a policy variable of equal importance is the composition of this R&D (Tassey 1999). Both econometric work and case studies have demonstrated the different but equally important roles of each phase of the R&D life cycle. Over this cycle, different classes of R&D funders and performers rise in importance, then give way to others. The availability and timeliness of these different participants determine the success or failure of technology-intensive industries relative to foreign competitors. This chapter is designed to provide a broad understanding of the nature of R&D expenditures and the implications of R&D expenditures for science and technology (S&T) policy.

Chapter Organization

This chapter is organized into five major parts that examine trends in R&D expenditures. The first and second parts look into R&D funded and performed solely in the United States. The first part contains information on economic measures of R&D spending in the United States and trends in financial support for R&D, giving particular attention to direct Federal R&D support as well as indirect fiscal measures to stimulate R&D growth. The second part describes trends in total R&D performance in the United States; areas addressed include industrial R&D performance and R&D performance by geographic location, character of work, and field of science.

The third part summarizes available information on R&D collaborations, alliances, and partnerships. It contains sections on intersector and intrasector R&D partnerships and alliances, including private-private, public-private, and public-public collaborations that have formed both domestically and internationally.

The fourth part compares R&D trends across nations. It contains sections on total and nondefense R&D spending, ratios of R&D to gross domestic product (GDP) among different nations, international R&D funding by performer and source (including information on industry subsectors and academic science and engineering fields), the character of R&D efforts (or R&D efforts separated into basic research, applied research, and development components), and international comparisons of government R&D priorities and tax policies.

The fifth part provides statistics on international R&D investment flows. It contains a review of the U.S. international R&D investment balance, discusses patterns in overseas and foreign R&D performed in the United States in terms of expenditures and facility placement, and offers a new Industry Globalization R&D (IGRD) index as a way of measuring which industries have adopted the most internationalized approach in their R&D activities.

R&D Support in the United States

Since 1994, R&D in the United States has risen sharply, from $169.2 billion to an estimated $264.6 billion in 2000.[1] In real terms (adjusting for inflation), this rise has been from $176.2 billion to $247.5 billion in constant 1996 dollars, reflecting an annual real growth rate of 5.8 percent. The increase of $71.3 billion 1996 dollars between 1994 and 2000 is the greatest single real increase for any six-year period in

[1]At the time this report was written, estimated data for 2000 were the latest figures available on R&D expenditures.